DEAD RECKONING;
OR,

DAY'S WORK.

BARRETT.

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DEAD RECKONING;

OR,

DAY'S WORK.

BY

EDWARD BARRETT,

LIEUT.-COMMANDER U. S. N.

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PREFACE.

By order of the Department, the greater portion of Volunteer Naval Officers present themselves to the author of this work for examination as to their professional qualifications.

Experience has shown to him the necessity of a concise work upon Navigation.

In the many examinations that have been made, there has been painfully apparent an inability to properly apply all the corrections to an observed Altitude, as also to work out "Dead Reckoning."

This Pamphlet is the Pioneer of a work upon "*Navigation*," which will fully and concisely exemplify all practical propositions.

/59

The formula of the Log Book is the same as that of the U. S. Navy, with the exception of a column for "Drift," introduced by the author.

Tables Nos. 1 and 2, of Bowditch, which require sixty-one pages for exemplification, have been condensed in this work into two pages.

EDWARD BARRETT,
Lieut.-Commander U. S. N.,
Commanding U. S. S. "Savannah."

October 3d, 1863.

DEAD RECKONING.

PRELIMINARIES.

Calculation of Sexagesimals.

1*st.—To reduce Sexagesimals to Units of the Least Denominations.*

Sexagesimals are numbers whose units are sub-divided into parts from 60 to 60 times less. Thus, the day being composed of 24 hours, each hour is divided into 60 equal parts, called minutes, and the minutes into 60 equal parts, called seconds, etc.

The same manner of sub-dividing is applied to the graduation of the circumference.

The circumference is divided into 360 equal parts, called degrees, each degree into 60 equal parts, called minutes, and each minute into 60 equal parts, called seconds.

REDUCE $2^h\,25^m\,43^s$ TO SECONDS.—Reduce the hours to minutes by multiplying the hours by 60; thus, 2 hours is equal to 120 minutes, which, added to the 25 minutes that accompany the hours, make 145 minutes. It can therefore be said that the proposed number is equal to 145 minutes, plus 43 seconds.

Multiply 145 minutes by 60 we obtain 8,700 for the corresponding number of seconds, which, added to 43 seconds gives 8,743 seconds as the number required.

2d.—Reciprocally.

Required the Number of Degrees, Minutes, and Seconds contained in 10,472 Seconds.—Since 60 seconds are equal to a minute, it is evident that by dividing the number by 60, we will obtain the number of minutes it contains. In effecting the division we find 174 as the quotient and 32 seconds remaining; therefore, in 10,472, there are 174 minutes, plus 32 seconds, but since there is required only 60 minutes to a degree, by dividing 174 by 60, we find that in 174 minutes there are 2° 54′; therefore, the number proposed equals 2° 54′ 32″.

Remarks.—We have stated that to extract the degrees contained in a number, such, for example, as 275 minutes, it suffices to divide the number by 60, therefore it is evident that to obtain the quotient of this division it is only necessary to divide by 6, the tens of the proposed number.

Thus, in taking the sixth of 27, we find 4 for quotient and 3 tens for remainder. This number of tens added to the units of the proposed number, gives a remainder of 35 minutes, therefore, the proposed number contains 4° 35′.

The rule is also applicable in extracting the minutes contained in the number of seconds.

3*d.*—*Addition.*

To add sexagesimals, write them so that the units of the same name will be under each other; then add the units of the least denomination, and write their sum under the corresponding unit when that sum is less than sixty, but if the sum is greater than sixty the minutes are extracted, and the number of seconds left are written under the column of seconds; carry the minutes extracted to the preceding column, and add them to the minutes of that column. It is thus that in the example, the sum of the seconds being 115, 55 seconds are written and 1 minute carried, because 115 seconds contain one minute and 55 seconds.

Act in like manner in the addition of column of minutes.

Example I.

$$\begin{array}{rrr} 31^\circ & 45' & 38'' \\ 42 & 38 & 22 \\ 6 & 24 & 55 \\ \hline 80^\circ & 48' & 55'' \end{array}$$

Example II.

$$\begin{array}{rrr} 1^{h} & 26^{m} & 41^{s} \\ 3 & 43 & 26 \\ 2 & 28 & 32 \\ \hline 7^{h} & 38^{m} & 39^{s} \end{array}$$

4th.—Subtraction.

To subtract sexagesimals, the units of the same name are written under each other, and the subtraction is proceeded with by operating separately on the units of the same name, as will be shown by the following examples:

Example I.

$$\begin{array}{rrr} 34^\circ & 28' & 52'' \\ 12 & 17 & 31 \\ \hline 22^\circ & 11' & 21'' \end{array}$$

Example II.

$$\begin{array}{rrr} 12^{h} & 42^{m} & 51^{s} \\ 7 & 28 & 19 \\ \hline 5^{h} & 14^{m} & 32^{s} \end{array}$$

Example III.

$$\begin{array}{rrr} 25^\circ & 22' & 19'' \\ 11 & 45 & 32 \\ \hline 13^\circ & 36' & 47'' \end{array}$$

Example IV.

$$\begin{array}{rrr} 12^h & 00^m & 00^s \\ 3 & 25 & 33 \\ \hline 8^h & 34^m & 27^s \end{array}$$

The calculation of the first two examples is not difficult; the excess of the number of seconds of the upper number over the seconds of the inferior number is written under the seconds. Operate in the same manner with the minutes and degrees. In the third and fourth examples the calculations require explanation. For instance, in the third example the seconds of the superior number being less than in the inferior number, 1′ is taken from the preceding 22′ and its value 60″ is added to the 19″ of that number, giving 79″, from which are taken the 32″ of the inferior number. We can here repeat the remark made in (2d), that the 1′ extracted is the same thing as taking 6 tens of seconds. The subtraction can therefore begin by the units, and the 1′ taken from the preceding number only after having made the calculation, consequently we will say, take 2 from 9 and there remains 7. 3 cannot be taken from 1, therefore, we take from the preceding number 1′, equal to 6 tens of seconds, which, added to 1 ten, gives 7 tens of seconds. Take 3 from 7, 4 remains. Passing to the minutes, say 5 from 1 (only 21 should be counted, as one has already been taken from 22) cannot be taken. Take the ten of a minute, equal to ten units, which, added to 1′, gives 11′. Take 5 from 11, 6 remains. 4 from 1 (because we have already taken 1′ of the 2 tens) cannot be done, therefore take 1°, equal to 6 tens of a minute, which, added to the 1 ten left, gives 7. Take 4 from 7, 3 remains. Passing to the degrees, we say, take 1 from 4, 3 remains, and 1 from 2 leaves 1. The remainder of the subtraction is 13° 36′ 47″.

Calculate the fourth example in like manner.

5th.—Multiplication.

To multiply sexagesimals by whole numbers, multiply separately each sexagesimal part, commencing by the least denomination, taking care to account for those to be retained, as we have already said in what precedes.

	Example I.	Example II.
Multiplicand	$3^h\ 49^m\ 57^s$	11° 44′ 52″
Multiplier	3	4
Product	$11^h\ 29^m\ 51^s$	46° 59′ 28″

	Example III.
Multiplicand	5° 38′ 16″
Multiplier	6
Product	33° 49′ 36″

In the first example say 3 times 7 are 21, write 1 and carry 2 tens. 3 times 5 are 15, which, added to the 2 tens retained, make 17 tens; but in 17, 6 is contained twice and 5 over; write 5 tens and carry twice 6 tens, equal 2′. 3 times 9 are 27, which, added to the 2 tens carried, makes 29. Write 9 and carry 2 tens. 3 times 4 are 12, and 2 carried make 14, but 14 tens contain twice 2 tens and 2 over. Write 2 tens and carry twice 6 tens, equal 2^h.

Remark.—To multiply sexagesimals by 60, it suffices to give the next greatest name to the sexagesimal parts, viz.: Change the seconds to minutes, the minutes to degrees or hours.

Thus the numbers	$34^{m}\ 25^{s}$	$5'\ 12''\ 17'''$
Multiplied by 60, give	$34^{h}\ 25^{m}$	$5^\circ\ 12'\ 17''$

6th.—Division.

To divide sexagesimals by whole numbers, apply the inverse rule of multiplication, viz.: divide separately each of the sexagesimal parts, beginning the calculation by the numbers on the left.

Example I.

$33^\circ\ 45'\ 28''$

Divided by 2

Quotient $16^\circ\ 52'\ 44''$

Example II.

$9^{h}\ 58^{m}\ 48^{s}$

Divided by 4

$2^{h}\ 29^{m}\ 42^{s}$

Example III.

$5^\circ\ 35'\ 25''$

Divided by 6

Quotient $0^\circ\ 55'\ 54''\ 10'''$

Example IV.

$24^{h}\ 42^{m}\ 11^{s}$

Divided by 5

Quotient $4^{h}\ 56^{m}\ 26^{s}\ 12'''$

The first example is calculated as follows:

The half of 3 is 1, and there remains a 10, equal to 10 units, which added to the three following units makes 13, whose half is 6 for 12. There remains 1°, whose value is 6 tens of minutes. Adding the 6 tens to the 4 tens of minutes which follow, we obtain 10 tens, whose half is 5. The half of 5 is 2 for 4, there remains 1′ equal to 6 tens of seconds. Adding the 6 tens of seconds to the 2 tens of seconds that follow, we obtain 8 tens, whose half is 4, the half of 8 is 4. In the third example, 6 in 5 will not go; write down the cypher under the degrees, there remains 5°, equal to 5 times 6 tens, or 30 tens of minutes, which, added to the 3 tens of minutes that follow, give 35 tens, whose 6th is 5 for 30; there remains 3 tens, which, added to 5′ following equal 35′ whose 6th is 5 for 30, and there remains 5. The 5′ remaining are equal 5 times 6 tens or 30 tens of seconds, which, added to the 2 tens of seconds following equal 32 tens, whose 6th is 5 for 30, consequently leaving 2 tens, which, added to the 5′ following give 25, whose 6th is 4 for 24, and 1″ remaining; the 1″ left is equal to 6 tens of tierces, whose 6th is 10‴, therefore the quotient of the division is expressed by 0° 55′ 54″ 10‴.

REMARKS.—To divide a sexagesimal by 60, it suffices to give to the different sexagesimal parts the signs of the parts sixty times less, *i. e.*, the hours become minutes, the minutes become seconds, the seconds become tierces, etc. Example,

	$5^\circ\ 13'\ 20'''$	$10^m\ 26^s\ 40^m$
Divided by	60	60
	$5'\ 13''\ 20'''$	$10^h\ 26^m\ 40^s$

7th.—To reduce to decimal parts of hours or degrees, any number of minutes, degrees, or seconds.

To reduce to decimals the sub-division of degrees or hours, remark that $60' = 1^\circ$, *i. e.*, 6 answers to one-tenth of a degree, therefore, in any number of minutes there are as many tenths of degrees as that number contains 6.′

Example I.	Example II.	Example III.
$36' = 0^\circ, 6$	$24' = 0^\circ, 4$	$48^m = 0^h, 8$

In like manner by dividing any number of seconds by 6 we obtain tenths of minutes.

8th.—Reciprocally.

To convert to minutes and seconds a decimal fraction of hours or degrees, multiply the fraction by 60, a calculation effected by multiplying the fraction by 6, and transporting the comma one figure to the right. The fraction is thus converted into minutes and decimal parts of minutes. Operating in like manner on the decimal parts of minutes, we obtain the seconds and decimal parts of seconds.

Example.—Reduce to degrees, minutes, and seconds, the decimal of 3° 254.

The number is composed of 3° + 0,254. Multiply the decimal by 6, and transport the comma one figure to the right. The proposed number will be 3° 15′, 24.

Decimals.

Decimal Fractions are those whose denominations are 10, 100, 1,000, or 10,000, etc.

Fractions with any other denominations are called Vulgar Fractions.

Decimal Notation is that kind of numbering in which ten units of an inferior name are equal in value to a unit of the next superior.

Decimals are separated from the integers, or whole numbers, by a period, and are placed on the right hand of them. They decrease in order from the unit place towards the right.

Hundred.	Tens.	Units.		Tenths.	Hundredths.	Thousandths.	Ten Thousandths.	Hundred Thousandths.
1	2	9	.	3	6	7	8	9

Cyphers on the left hand of a decimal diminish its value, but on the right hand do not alter its value. For instance,

		Tenth.	Hundredth.
0	.	0	1

		Tenth.	Hundredth.	Thousandth.
0	.	0	0	1

		Tenth.	Hundredth.
0	.	1	0

		Tenth.	Hundredth.	Thousandth.
0	.	1	0	0

As decimals are parts of a unit divided into either 10, 100, 1,000, 10,000 parts, etc., according to the place in the fractional number, therefore they are read like whole numbers, only calling them so many parts of 10, 100, 1,000, 10,000, etc.

Thus a decimal fraction of one, two, three, four, represents, according to their place in the fractional number, so many parts of Ten, Hundred, Thousand, and Ten Thousand, viz.: 10 *Ten*th, 100 *Hundred*th, 1,000 *Thousand*th, 10,000 *Ten Thousand*th.

Addition of Decimals.

Rule.—Write the numbers so that like names will stand under like names; draw a line under the column, and proceed to add the same as in addition of whole numbers. The decimal separating points will range straight in the column.

Example I.	Example II.—Miles.
3720.45	143.206
25.0036	.003
4179.802	32.15
3.6284	25.03
7928.8840	200.389

Proofs, same as in addition of whole numbers.

Subtraction of Decimals.

Rule.—Write the figures of the same denomination, or of like names, and the separating points, directly under each other, and proceed to subtract as in whole numbers.

Example I.	Example II.
8972.6834	723.58
3683.7213	432.693
5288.9621 Dif.	290.887 Dif.

Proofs, same as in subtraction of whole numbers.

Multiplication of Decimals.

Rule.—The numbers are multiplied together as in whole numbers. Point off as many decimals from the right hand as there are decimals in both factors together. When there are not as many figures in the product as there must be decimals, prefix as many cyphers to the left hand as there are decimals.

Example I.	Example II.
Multiply 23.08	Multiply .17
by 5.52	by .06
4616	.0102
11540	
11540	
127.4016	

Division of Decimals.

Rule.—Divide as in whole numbers, observing that the number of decimals in the Quotient must be equal to the excess of the number of decimals of the Dividend above those of the Divisor.

When the Divisor contains more decimals than the Dividend, cyphers must be affixed to the right hand of the latter to make the number equal or exceed those of the Divisor.

Example I.

Divide 29.250 by 6.50.

6.50)29.250(4.5
26.00
3250
3250

Example II.

Divide 6.2 by .0124.

.0124)6.200000(500.00
6.20

Proof.—Multiply the Quotient by the Divisor. The Product will be the Dividend.

Instance: .0124
500.00
6.200000

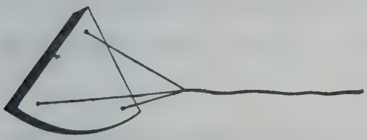
Log — Reel — Glass.

The first notion of Practical Navigation imparted to aspirant sailors is that derived from the speed and course of the ship, and wherein astronomical observations are not required.

The rule to find a ship's position by this method is called Dead Reckoning.

The speed is measured by the log and glasses, and the course is given by the compass.

The Log is as follows, viz., a thin board of triangular form, called a log board, whose base is leaded in such a manner that two-thirds of the board will be vertically immersed in the water during the experiment. From the two extremities of the base are ends of lines, to which a plug is secured at a short distance from the log.



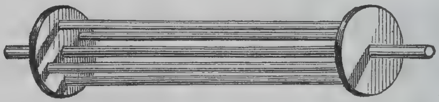
The log line, 150 fathoms long, is secured to the top of the board, and has fastened to it a socket, at the same distance from the board as the plug, which, when used, is inserted into it.

On the log line, one ship's length distance from the board, a white rag is placed, and from that white rag the log line is marked in distances equal to the one hundred and twentieth part of a mile.

Those marks are called "knots," and are subdivided into "half knots."

The Reel is made of two circular boards, connected together by four cylindrical rods.

It revolves on the centre around an iron rod to which are attached two handles.



The log line is wound around the reel.

When the log is to be "hove," the order is given to "hold the reel."

The person who heaves the log inserts the plug in the socket, and takes in hand a sufficient quantity of line to heave the board clear of the ship. The log is hove from over the lee quarter, and near the stern.

The log board is stopped by the resistance of the water. Experience has shown that the log is out of the eddy of the ship's wake, when the log is a ship's length from the stern. When about heaving the log, the person calls the attention of the glass holder, by saying, "watch." When the white rag glides through his hands, he gives the word, "turn," and the glass holder replies, "done."

The Glass is turned at the command "turn," and when the sand has run out, the holder says, "stop." The reel is checked, and the log heaver gives a sudden jerk to the line to disengage the plug. The last mark run off shows the number of knots, and the distance of that mark from the reel is estimated in fathoms. The knots and fathoms show the distance the ship has run in the preceding hour, if the wind has been constant.

Allowance must be made for the making and reducing sail, and the strength of the wind.

The line should be paid out as fast as the "board" will take it; if the board is permitted *to carry the line from the reel* it will come home with a false reckoning.

In casting the log there are two glasses used, viz., a 14 seconds glass, and a 28 seconds glass.

The knots on a log line for a 28 seconds glass are marked at distances, 45 feet apart, and when the 14 second glass is used, the intermediate distances between the knot marks, or the half knots, as they are called, are counted as knots. When a ship's speed exceeds four knots, use the short glass. The log line should be frequently examined to verify the length of the knots.

To do this, two copper nails should be driven in the deck 45 feet apart, and the lines verified by them.

Glasses should be verified by a "second hand" watch, or by the oscillation of the bullet in smooth weather, one full oscillation, "going" and "coming," being counted as two seconds.

The distances marked on a log line represent the same portions of a mile, that the time taken for the sand to run through the glass bears to an hour of time; therefore, the number of distances "run off" the log line during the time the sand is running through the glass, represents the number of miles a ship has sailed in the previous hour, providing the wind has been steady.

In the event of losing the log, another simple way may be resorted to for finding the ship's speed, viz., throw a piece of wood from the lee bow of ship; count the number of seconds it takes to reach the stern ; the speed of the vessel is obtained by multiplying the length of the vessel by two, and dividing the product by three times the number of seconds it required the board to reach the stern of the ship.

Mariners' Compass.

The compass consists of a magnetic needle balanced on a pivot, and attached to the under side of a card, in such a way that both traverse together, the needle, itself, being out of sight. Upon the surface of the card is engraved a radiating diagram, dividing the whole circle of the horizon into 32 parts, called "points." The North always, and sometimes the South points, have on their indicators an arabesque figure, or "*fleur de lis*," to attract particular attention.

At a right angle to the North and South points, are the indicators for the East and West.

The four points are called the "cardinal points," and communicate their names to all others.

For instance, the point equi-distant from the North and East points is called North-East; and the point equi-distant from the North and West points is called North-West; the South-East and South-West points are also equi-distant from the South and East, and from the South and West points. The point immediately between North and North-East is called North-North-East.

The word "North" is repeated, indicating the point equi-distant between North and North-East.

The point equi-distant between North-east and East is known as East-North-East, and here we have the word "East" repeated.

The point next to North, to the eastward, is known as North by East, and next to East to the northward as East by North.

The points next to North-East are known as North-East by North, and North-East by East, according to the tendency of the indicator to the northward or eastward of that point. See Diagram **C.**

To box the compass, is to know all the different points.

Mariners' compasses are placed in boxes by means of two concentric hooks, called "Gimbals."

These are so placed as to cross each other, and support the compass-box immediately in the centre of the two, so that, whichever way the vessel may "roll" or "lurch," the card is always in a horizontal position, and a certain point giving the direction of the head of the ship.

The compass is placed in a stand called the "binnacle," which is placed near the ship's wheel.

Log Slate and Log Book.

When leaving port, on a cruise or voyage, it becomes necessary, for the purpose of keeping the reckoning of a vessel, to note her speed and course, in order to find her position by dead reckoning.

The position so found, frequently operates as a check to any errors of navigation by observation of heavenly bodies.

Previous to noting the course and speed the departure is taken.

To do this, take the bearings by compass and calculate the distance from some prominent point, such as a lighthouse or headland, whose latitude and longitude is well known.

The bearing of the object reversed is taken as first course, and the distance of the object is the distance for first course.

Every hour subsequent to the taking of the departure, the log will be hove, and the course and distance made noted. If the vessel has made two courses during the hour, note them, and allow for the distance, taking into consideration the speed and length of time sailed on that course.

The speed and courses are marked on a log slate kept on deck for that purpose.

The slate and log book are ruled alike.

The course, speed and remarks, entered on the slate, are copied into log book every morning.

The formula on the following page, to which is added the column of drift, is the form of log book in use in the United States navy.

The watches on ship board are divided according to the time stated in the "Remarks."

All that transpires, viz., making and reducing sail, and all uncommon occurrences are noted by the officer of the watch, and entered in the "Remarks," which are signed by the officers, who are the responsible parties.

The log begins at midnight—civil time.

Definition.

The latitude of a place is its distance from the equator. It is the angular distance from the equator, measured on a secondary to it.

The longitude of a place is its distance from a meridian, called the first meridian. It is the arc of the equator included between its meridian and the fixed meridian, for instance, the meridian

Log of United States Ship *Commanded by*

H.	Knots.	Fathoms.	Courses.	Drift.	Wind.		Weather.	Temperature.		Barometer.	REMARKS ON THIS DAY OF 18 .
					Directions.	Force.		Air.	Water.		
A.M.											
1											Commences
2											
3											
4											
5											From 4 to 8.
6											
7											
8											
9											From 8 to Meridian.
10											
11											
12											
Distance per Log. *Latitude D. R.* *Longitude D. R.* *Latitude observed.* *Longitude.* *Current.* *Variation.*											From Meridian to 4.
P.M.											From 4 to 6.
1											
2											
3											
4											
5											From 6 to 8.
6											
7											
8											
9											
10											
11											From 8 to Mid.
12											

The Log.

which we use as a first meridian. Longitude is also the angle formed by the meridian of the place, and the first meridian. Departure is the number of miles sailed on an East or West course.

Course.

The course is the angle formed by the meridian and the direction followed by the vessel.

This angle is easily calculated, when the point toward which the vessel is directed is known.

It suffices to count the number of points included between the North or the South up to the point steered, and to multiply the number by 11° 15′, the angle included between two consecutive points.

Example I.

What course answers to W. S. W., 2° W.?

Answer. Each point equals 11° 15′

From South to W. S. W., there are
6 points, 6

67° 30′

As the point we consider is 2° beyond W. S. W. + 2°

The course required is S. 69° 30′ W.

Example II.

What course answers to N. E. ½ ~~E~~N. ?

Answer. Each point equals	11° 15′
From N. to N. E. there are 4 points	4
Therefore from N. to N. E.	45° 00′
As the point considered is a ½ point nearer North than N. E. we will subtract from the angle the value of a ½ point	5° 37′
The course required is	N. 39° 23′ E.

Reciprocally.

The course being given to find the point corresponding to it.

The most convenient and easiest way to work out the question consists in remembering that from leaving the meridian, the intervals of the points counted by twos are of 22° 30′; 45°: 67° 30′, and 90°.

Suppose, for instance, the point corresponding to N. 56° 15′ W. is required. We perceive that the angle of N. W. is 45°; that from N. W. to N. 56° 15′ W. there remain 11° 15′, equal to one point, therefore, the course will be one point beyond N. W., or N. W. by W.

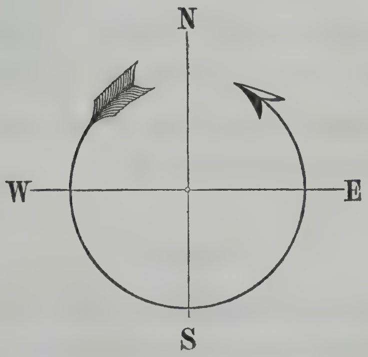
Variation.

If the magnetic needle pointed to the North and South of the world, it would suffice to read on the compass the ship's heading, to know the direction she follows. But the needle of the compass does not coincide exactly with the meridian. It varies to the right or to the left by a quantity called "variation" or "declination."

This deviation is not constant; it varies according to place, time and weather. The variation is said to be easterly, when the North of the compass deviates to the RIGHT of the North of the world; westerly, when the North of the compass deviates to the LEFT of the North of the world.

Nautical charts give an approximate variation for different parts of the world.

DIAGRAM A.



To correct a compass course for variation, apply the correction as shown by Diagram **A.**

For instance, if the variation is westerly, correct the course in the direction of the arrow, viz., to the left.

Example I.

The compass course being N. N. W., and the variation a half point westerly; by applying the ½ point in the direction of the arrow, we obtain the correct course, N. N. W. ½ W.

Example II.

The compass course being S. S. W., and the variation ¾ point westerly; by applying the ¾ point in the direction of the arrow, we obtain the correct course, S. by W. ¼ W.

Example III.

The compass course being S. by E. ¼ E., and variation 1 point westerly, by applying the one point in direction of the arrow, we obtain the correct course, S. S. E. ¼ E.

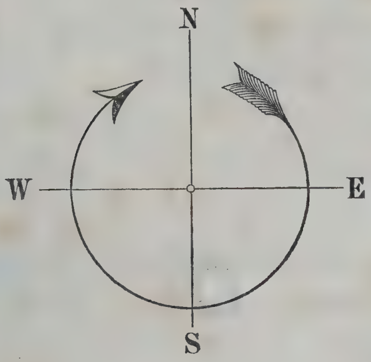
Example IV.

The compass course being East by North, and variation a half point westerly, by applying the

½ point in the direction of the arrow, we obtain the correct course, E. N. E. ½ E.

If the variation is easterly we will correct the compass courses in direction of the arrow in the following diagram, viz.: to the right.

DIAGRAM B.



Example I.

Compass course N. by E. ¼ E., variation ¾ point easterly; apply the ¾ point in the direction of the arrow, and we obtain the correct course, N. N. E.

Example II.

Compass course S. E. by E., variation ¼ point easterly: by applying the ¼ point in the direction of the arrow, we obtain the correct course, S. E. ¾ E.

Example III.

Compass course S. by W. ½ W.
Variation ½ point easterly.
Apply the ½ point in direction of arrow.
Correct course S. S. W.

Example IV.

Compass course W. N. W. ¼ W.
Variation ¾ point easterly.
Apply the ¾ point in direction of arrow.
Correct course N. W. by W. ½ W.

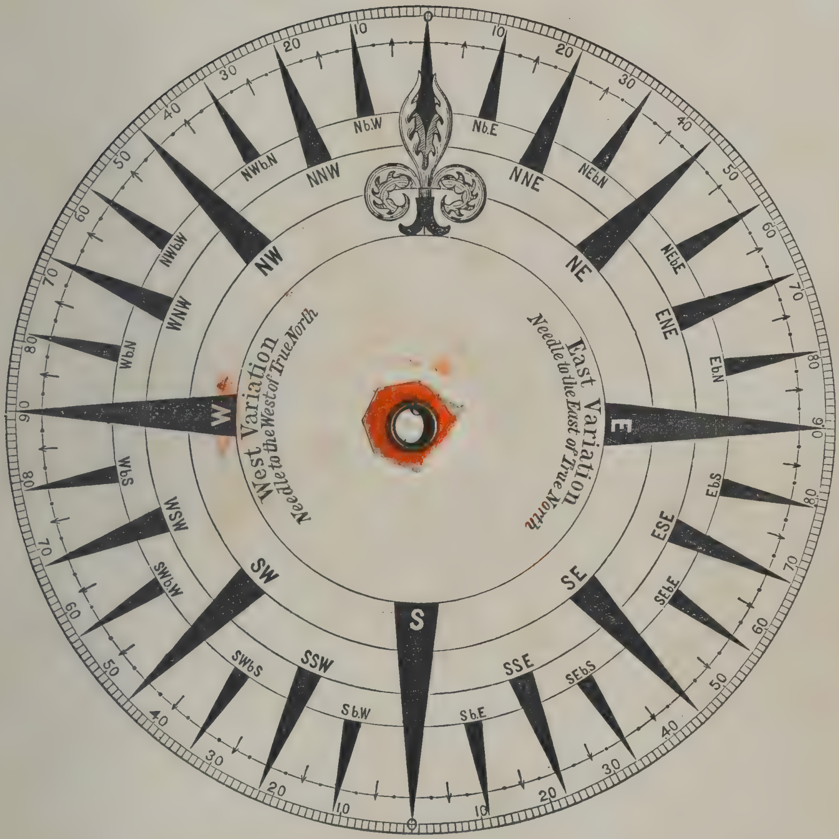
The Diagram and Indicator **C**, will facilitate correcting courses.

To use it, point the indicator to the compass course sailed; if the variation is easterly, move the indicator to the right, to the amount of variation to be applied, viz.:

If the variation is a half point easterly, move the indicator a half point to the right, and the course it points to will be correct course.

If variation is westerly, move indicator to the left, and obtain correct course.

DIAGRAM C.


N b.W
N b.E
NNW
NNE
NWb.N
NEb.N
NW
NE
NWbW
NEbE
WNW
ENE
W b.N
E b.N
W
E
W b.S
E b.S
WSW
ESE
SWb.W
SEb.E
SW
SE
SWb.S
SEb.S
SSW
SSE
S b.W
S b.E
S
0
10
20
30
40
50
60
70
80
90
West Variation
Needle to the West of True North
East Variation
Needle to the East of True North

Drift.

If the vessel followed the direction indicated by the bow, it would suffice to correct the compass course for variation to know the true course.

But the vessel ceding to the oblique impulsion of the wind, glides laterally, and thus deviates from the direction it appears to follow. The direction, and the amount of this deviation, which is called "drift," depend upon the state of the sea, the intensity of the wind, and its direction relatively to that of the ship. The true course followed by the vessel is evidently indicated by the track of foam, called "wake," which it leaves astern. Consequently, by measuring the angle made by the wake, and the keel of the vessel, the amount of drift will be found. It is manifest that the direction of the drift is always opposed to that of the "tack" on which the vessel sails; that is to say, if the wind is from "starboard" the drift will be to "port," and *vice versa.*

To correct the course for the effects of drift, correct as if for variation, by considering the drift to port as westerly, and drift to starboard as easterly.

Ordinarily, the courses are affected at the same time by drift and variation; therefore, the two corrections should be made simultaneously.

To do this, if the drift and variation affect the course in the same direction, they are added together, and the compass course is corrected for the sum of the two quantities.

If, however, the drift and variation are contrary in their effects, the difference between them is taken, and the compass course is corrected by that difference, and in the direction of the greater.

Example I.

Compass course N. by E. ½ E.

Variation, 1 point westerly (to the left).

Drift, ½ point port (to the left).

The true correction to be applied for variation and drift will be 1½ points to the left, giving as true course, NORTH.

Example II.

Compass course S. S. W.

Variation, ¼ westerly (to the left).

Drift, ½ starboard (to the right).

The true correction to be applied for variation and drift will be ¼ point to the right, giving as true course, S. S. W. ¼ W.

Example III.

Compass course S. E.

Variation, 1 point easterly (to the right).

Drift, ½ point starboard (to the right).

The true correction to be applied for variation and drift will be 1½ points to the right, giving as true course, S. S. E. ½ E.

Example IV.

Compass course N. by W.

Variation, ¾ easterly (to the right).

Drift, ¼ port (to the left).

The true correction to be applied for variation and drift will be ½ point to right, giving as true course, N. ½ W.

To Find Ship's Position by Dead Reckoning.

PROBLEM I.

To find ship's position when sailing true North or true South.

When a vessel steers true North or true South, it always remains on the same meridian; consequently the longitude remains the same, while the latitude increases or diminishes as the vessel recedes from, or approaches the equator. Each mile the vessel sails represents one minute on the meridian. It can therefore be said that the latitude increases or diminishes in minutes as there have been miles sailed to the North or to the South. When knowing the different latitude, the latitude arrived at will be found by the following rule.

1*st.* If the latitude of the place sailed from, and the difference of latitude made, are of the same name, viz., both North or both South, they are added together to find "latitude in," which will be of the same name also.

2*d.* If the latitude of the place sailed from, and the difference of latitude are of different names, viz., one North and one South, subtract the lesser from the greater, the remainder will be "latitude in," and of the same name as the greater.

Example I.

Latitude departed from,	36° 28′ N.
Longitude,	17° 54′ W.
Vessel sails 146 miles true North,	
Required "latitude in,"	
Diff. latitude 146′ N.,	= 2° 26′ N.
Latitude departed from,	36° 28′ N.
"Latitude in" (Sum),	38° 54′ N.

Example II.

Latitude departed from,	16° 11′ S.
Longitude,	55° 18′ E.
Vessel sails 205 miles true North,	
Required "latitude in,"	
Diff. latitude, 205′ N.,	= 3° 25′ N.
Latitude departed from,	16° 11′ S.
"Latitude in" (Difference),	12° 46′ S.

Example III.

Latitude departed from,	21° 44′ S.
Longitude,	36° 11′ W.
Vessel sails 135 miles true South,	
Required "latitude in,"	
Diff. latitude, 135′ S.,	= 2° 15′ S.
Latitude departed from,	21° 44′ S.
"Latitude in" (Sum),	23° 59′ S.

Example IV.

Latitude departed from,	48° 23′ N.
Longitude,	53° 15′ E.
Vessel sails 196 miles true South,	
Required "latitude in,"	
Diff. latitude, 196′ S.,	= 3° 16′ S.
Latitude departed from,	48° 23′ N.
"Latitude in" (Difference),	45° 07′ N.

Example V.

Latitude departed from,	1° 05′ N.
Longitude,	19° 15′ E.
Sails true South 213 miles,	
Required "latitude in,"	

Diff. latitude, 213′ S., = 3° 33′ S.
Latitude departed from, 1° 05′ N.

"Latitude in" (Difference), 2° 28′ S.

Example VI.

Latitude departed from, 2° 16′ S.
Longitude, 11° 50′ E.
Sails true North 205 miles,
Required "latitude in,"
Diff. latitude, 205′ N., = 3° 25′ N.
Latitude departed from, 2° 16′ S.

"Latitude in" (Difference), 1° 09′ N.

PROBLEM II.

To find the position of a vessel when sailing true East or true West.

When a vessel sails true East or true West, it remains always the same distance from the equator, consequently the latitude remains the same, whilst the longitude increases or diminishes as the ship recedes from or approaches the meridian of Greenwich. The difference of longitude, however, is not immediately given by the departure, or the eastings or westings made, as the difference of latitude is, by the northings or southings, because it is only on the equator, or in low latitudes, that a mile in the direction of East or West is equal to a minute of longitude.

The conversion of the departure, or miles East or West, into minutes of longitude, requires a particular calculation.

For this reduction, use Table II.

Opposite to each latitude will be found a number with which to multiply the departure or miles of eastings or westings to obtain the corresponding number of minutes of longitude.

Example I.

Latitude departed from, 35°. The vessel sails 139 miles due East.

Required the difference of longitude.

Departure, or miles to eastward, 139 miles.
Table II., for 35°. Multiplier, 1.22

278
278
139

Product, 169.58
Diff. longitude, 169′ .6 = 2° 49′ .6

Example II.

Latitude departed from, 45°. Vessel sails 106 miles due West.

Required the difference of longitude.

Departure, or miles to westward 106 miles.

Table II., for 45° Multiplier, 1.41

106
424
106

Product, 149.46

Different longitude, 149 .5 = 2° 29′ .5

Knowing the difference of longitude, the "longitude in" will be found by the following rule:

If the longitude departed from, and the difference of longitude are of the same name, namely, both East or both West, add them together to obtain the "longitude in," which will be of the same name. If, however, the sum obtained is greater than 180°, subtract it from 360° to obtain the "longitude in," which will be of a different name from the longitude departed from.

But if the longitude departed from, and the difference of longitude are of different names, subtract the lesser from the greater, the remainder will be the "longitude in," and of the same name as the greater.

Example I.

A vessel sails from
Lat. 48° 15′ S.
Long. 30° 23′ W.
and makes 125 miles true West.

Required "longitude in."

Miles to westward, 125 Diff. long., 186.2 = 3° 06′ .2 W.
Table II., 48° Multiplier, 1.49 Long. dept. from, 30° 23′ W.

Product, 186.25 "Long. in" (sum), 33° 29′ .2 W.

Example II.

A vessel sails from
Lat. 50° 08′ N.
Long. 178° 54′ E.
and makes 108 miles true East.

Required "longitude in."

Miles to eastward, 108 Diff. long., 167.4 = 2° 47′ .4 E.
Table II., 50° Multiplier, 1.55 Long. dept. from, 178° 54′ E.

Product, 167.40 Long. arr. in (sum), 181° 41′ .4 E.
Subtract from 360°

"Long. in" (sum), 178° 18′ .6 W.

Example III.

A vessel sails from $\left\{\begin{array}{l}\text{Lat.}\quad 12^\circ\ 17'\ \text{N.}\\ \text{Long.}\ 26^\circ\ 45'\ \text{E.}\end{array}\right\}$ and makes 134 miles true West.

Required "longitude in."

Miles to westward, 134 Diff. long., 136′.7 = 2° 16′ .7 W.
Table II., 12° Multiplier, 1.02 Long. dept. from, 26° 45′ E.
Product, 136.68 "Long. in" (diff.), 24° 28′ .3 E.

Example IV.

Vessel sails from $\left\{\begin{array}{l}\text{Lat.}\ \ 44^\circ\ 55'\ \text{S.}\\ \text{Long.}\ \ 1^\circ\ 18'\ \text{W.}\end{array}\right\}$ and makes 153 miles due East.

Required "longitude in."

Miles to eastward, 153 Diff. long. 220′. 32 = 3° 40′ .3 E.
Table II., 46° Multiplier, 1.44 Long. dept. from, 1° 18′ W.
Product, 220.32 "Long. in" (diff.), 2° 22′ .3 E.

PROBLEM III.

To find a vessel's position when sailing on an oblique course.

1*st.* Correct the course for variation and drift.

2*d.* By means of Table I., determine the northing, southing, easting, or westing, corresponding to the course made.

3d. With the latitude sailed from, and the miles of the northing or southing representing the minutes of the difference of latitude, determine the "latitude in" by conforming to precept of Problem I.

4th. With the latitude sailed from, and the "latitude in," find the middle latitude, obtained by adding the latitudes together if of the same name, and dividing the same by two.

If latitude sailed from, and "latitude in," are of different names, subtract the lesser from the greater, and take half the difference.

5th. Seek in Table II. for the multiplier corresponding to the middle latitude, and multiply the departure by this factor to find the difference of longitude.

6th. With the longitude sailed from, and the difference of longitude, calculate the "longitude in," by conforming with the precepts of Problem II.

Example I.

A ship sails from {Lat. 30° 20′ N. / Long. 42° 11′ W.} and makes 112 miles on a N. by E. ½ E. course.

Variation, ½ point Westerly; drift, ¾ points ~~Easterly~~ Starboard.

1*st.* Correct the course.

Compass course, N. by E. ½ E.
Drift, ¾ ~~Easterly~~ Starboard (right).
Variation, ½ Westerly (left).
} Remains ¼ Easterly (right).
Corrected course (Sum), N. by E. ¾ E.

2*d.* Find the northing or southing, easting or westing, corresponding to the course.

Dist.	Course.	N.	E.
100		94.2	33.7
10		09.4	03.4
2		00.9	00.3
	(Sum),	104.5	37.4

Miles North, 104.5. Miles East, 37.4

3*d.* To find "latitude in."

Latitude sailed from,		30° 20′ N.
Diff. latitude, 104.5	=	1° 44′ .5 N.
"Latitude in"	(Sum),	32° 04′ .5 N.

4th. Find middle latitude.

Latitude sailed from,	30° 20′ N.
"Latitude in,"	32° 04′ .5 N.
(Sum),	62° 24′ .5
Middle latitude,	31° 12′ .2

5th. To find difference of longitude.

Dep. or miles East,	37
Table II., 31°, Multiplier,	1.17
Product (Diff. longitude),	43′ .29 E.

6th. To find "longitude in."

Longitude sailed from,	42° 11′ W.
Diff. longitude,	43′ .3 E.
"Longitude in" (Diff.),	41° 27′ .3 W.

Example II.

A vessel sails from { Lat. 1° 15′ N. / Long. 18° 31′ E. } and makes 196 miles on a S. by E. ½ E. course.

Variation, 1¾ point Westerly; Drift, ½ point Starboard ~~Easterly~~.

Required, the position of the vessel.

1st. Correct the course.

Compass course, S. by E. ½ E.
Correct course (Sum), S. S. E. ¾ E.
Drift, ½ ~~Easterly~~ Starboard (right), } remains 1¼ points
Variation, 1¾ Westerly (left), } Westerly (left).

2d. Find Northing, Southing, Easting, or Westing, corresponding to the course.

DIST.	COURSE.	S.	E.
100		85.8	51.4
90		77.2	46.3
6		5.1	3.1
	(Sum),	168.1	100.8

Miles South, 168.1. Miles East, 100.8.

3d. To find "latitude in,"

Latitude sailed from,		1° 15′ N.
Diff. latitude, 168,		= 2° 48′ S.
"Latitude in"	(Diff.),	1° 33′ S.

4th. To find middle latitude.

Latitude sailed from,	1° 15′ N.
"Latitude in"	1° 33′ S.
Diff.,	18′
Middle latitude,	9′

5th. To find difference of longitude.

The latitude being very small, the multiplier corresponding to the middle latitude is 1, that is, the miles of departure and the difference of longitude are the same.

Departure, (miles), 100.8 = 1° 40′ . 8 E.

6th. To find the "longitude in."

Longitude sailed from,		18° 31′ E.
Diff. longitude,		1° 40′ .8 E.
"Longitude in"	(Sum),	20° 11′ .8 E.

PROBLEM IV.

To find the position of a vessel that has sailed on several courses.

When at sea, and far from land, we are satisfied with determining the position of the vessel every day at meridian.

In the course of 24 hours, owing to the changes of the wind, or other influences, we are frequently obliged to sail on several different courses.

Having estimated the number of miles made on each course, Required, the position of the ship.

Correct the courses for variation and drift. Seek in Table I. for the northings or southings, or eastings or westings, corresponding to each course. Draw four columns. In the first column place the northings corresponding to each course; in the second column place the southings; in the third column place the eastings; and in the fourth column place the westings.

Add up the miles contained in each column, and obtain the difference between the northings and southings, which will be the difference of latitude, and of the same name as the greater; then obtain the difference between the eastings and westings, which difference will be the departure, and of the same name as the greater.

The miles are considered the result of a single course, and the Problem is solved in the same manner as the preceding one.

Example.

A vessel sails from { Lat. 29° 20′ N. / Long. 25° 05′ E. } and makes the following compass courses:

Variation 1½ point Westerly (left).

COMPASS COURSES.	DRIFT.	DIST.
N. N. E. ¾ E.	1 point ~~E.~~ (right). Std	23
N. E. ¼ E.	¾ point ~~E.~~ (right). Std	35
S. E. ½ E.	½ point ~~W.~~ (left). Pt	40
S. S. W. ½ W.		19

Arrange the calculation as follows:

COR'CT COURSES.	DIST.	N.	S.	E.	W.
N. N. E. ¼ E.	20	18.1	"	08.6	"
	3	2.7		01.3	
N. E. ½ N.	30	23.2	"	19.0	"
	5	03.9		03.2	
E. S. E. ½ E.	40	"	11.6	38.3	"
S. by W.	10	"	09.8	"	02.0
	9		08.8		01.8
		47.9	30.2	70.4	03.8
		30.2		3.8	

Diff. latitude, 17.7 N. Dep., 66.6 E.

Lat. sailed from, 29° 20′ N.
Diff. latitude, 18′ N.

"Latitude in" 29° 38′ N.

Sum of lat's, 58° 58′

Middle latitude, 29° 29′

Table II., the Mulplier for 29° is, 1.14
Departure, 66.06

Product, 75.924

75.924 = 1° 15′ .9 E., diff. longitude.
25° 05′ .0 E., longitude sailed from.

26° 20′ .9 E., "longitude in."

PROBLEM V.

To find a ship's position in making an allowance for current.

When a vessel is acted upon by currents, it drifts in their direction with a speed equal to that with which the current moves, and consequently there is a new movement which must be added to that of the vessel to obtain the positive direction in which it moves.

To do this, it suffices to consider the particular action of the current as an involuntary course made by the ship.

Example.

* A vessel sails N. E. ½ N. E., Dist. 35 miles, Drift 1¼ pt. W. P.
" " S. E. ¾ E., " 40 " " ½ " E. S.

It has been observed that a true W. S. W. current prevails in certain portions of the ocean, running at the rate of 2 (two) knots an hour, and a vessel was 18 hours under its influence.

Variation 1¾ point Westerly.

CORRECT COURSES.	DIST.	N.	S.	E.	W.
N. ½ E.	30	29.8	“	2.9	“
	5	05.0		0.5	
S. E. ½ S.	40	“	30.9	25.4	“
Current, W. S. W.	30	“	11.5	“	27.7
	6		2.3		5.5
		34.8	44.7	28.8	33.2
			34.8		28.8
Diff. latitude,			9.98	Dep.,	4.4 W.

The calculation can be continued as in the preceding Problem.

TABLES.

TABLE I.

COURSES CORRESPONDING TO THE POINTS.

	1/4		1/2		3/4		1		1 1/4		1 1/2		1 3/4		2	
	N. ¼ E. N. ¼ W. S. ¼ E. S. ¼ W.		N. ½ E. N. ½ W. S. ½ E. S. ½ W.		N. ¾ E. N. ¾ W. S. ¾ E. S. ¾ W.		N. by E. N. by W. S. by E. S..by W.		N byE.¼E. NbyW¼W S. byE.¼E. S.byW¼W		N. byE.½E NbyW½W S. by E.½E S byW½W		N.byE.¾E. NbyW¾W S. byE.¾E. S.byW¾W		N. N. E. N. N. W. S. S. E. S. S. W.	
DISTANCE.	0 Point.						1 Point.								2 Points	
	1/4		1/2		3/4		0		1/4		1/2		3/4		0	
	Lat.	Dept	Lat.	Dept	Lat.	Dept	Lat	Dept	Lat.	Dept	Lat.	Dept	Lat.	Dept.	Lat.	Dept.
100	99.9	04.9	99.5	09.8	98.9	14.7	98.1	19.5	97.0	24.3	95.7	29.0	94.2	33.7	92.4	38.3
200	199.8	09.8	199.0	19.6	197.8	29.3	196.2	39.0	194.0	48.6	191.4	58.1	188.3	67.4	184.8	76.5
300	299.6	14.7	298.6	29.4	296.8	44.0	294.2	58.5	291.0	72.9	287.1	87.1	282.5	101.1	277.2	114.8
10	10.0	00.5	10.0	01.0	09.9	01.5	09.8	02.0	09.7	02.4	09.6	02.9	09.4	03.4	0.92	03.8
20	20.0	01.0	19.9	02.0	19.8	02.9	19.6	03.9	19.4	04.9	19.1	05.8	18.8	06.7	18.5	07.7
30	30.0	01.5	29.9	02.9	29.7	04.4	29.4	05.9	29.1	07.3	28.7	08.7	28.2	10.1	27.7	11.5
40	40.0	02.0	39.8	03.9	39.6	05.9	39.2	07.8	38.8	09.7	38.3	11.6	37.7	13.5	37.0	15.3
50	49.9	02.5	49.8	04.9	49.5	07.3	49.0	09.8	48.5	12.1	47.8	14.5	47.1	16.8	46.2	19.1
60	59.9	02.9	59.7	05.9	59.4	08.8	58.8	11.7	58.2	14.6	57.4	17.4	56.5	20.2	55.4	23.0
70	69.9	03.4	69.7	06.9	69.2	10.3	68.7	13.7	67.9	17.0	67.0	20.3	65.9	23.6	64.7	26.8
80	79.9	03.9	79.6	07.8	79.1	11.7	78.5	15.6	77.6	19.4	76.6	23.2	75.3	27.0	73.9	30.6
90	89.9	04.4	89.6	08.8	89.0	13.2	88.3	17.6	87.3	21.9	86.1	26.1	84.7	30.3	83.1	34.4
1	01.0	00.0	01.0	00.1	01.0	00.1	01.0	00.2	01.0	00.2	01.0	00.3	00.9	00.3	00.9	00.4
2	02.0	00.1	02.0	00.2	02.0	00.3	02.0	00.4	01.9	00.5	01.9	00.6	01.9	00.7	01.8	00.8
3	03.0	00.1	03.0	00.3	03.0	00.4	02.9	00.6	02.9	00.7	02.9	00.9	02.8	01.0	02.8	01.1
4	04.0	00.2	04.0	00.4	04.0	00.6	03.9	00.8	03.9	01.0	03.8	01.2	03.8	01.3	08.7	01.5
5	05.0	00.2	05.0	00.5	04.9	00.7	04.9	01.0	04.9	01.2	04.8	01.5	04.7	01.7	04.6	01.9
6	06.0	00.3	06.0	00.6	05.9	00.9	05.9	01.2	05.8	01.5	05.7	01.7	05.6	02.0	05.5	02.3
7	07.0	00.3	07.0	00.7	06.9	01.0	06.9	01.4	06.8	01.7	06.7	02.0	06.6	02.4	06.5	02.7
8	08.0	00.4	08.0	00.8	07.9	01.2	07.8	01.6	07.8	01.9	07.7	02.3	07.5	02.7	07.4	03.1
9	09.0	00.4	09.0	00.9	08.9	01.3	08.8	01.8	08.7	02.2	08.6	02.6	08.5	03.0	08.3	03.4
DISTANCE.	Dept.	Lat.	Dept.	Lat.	Dept.	Lat.	Dept	Lat.	Dept.	Lat.	Dept	Lat.	Dept.	Lat.	Dept.	Lat.
	3/4		1/2		1/4		0		3/4		1/2		1/4		0	
	7 Points.								6 Points.							
	E. ¼ N. W. ¼ N. E. ¼ S W. ¼ S.		E. ½ N. W. ½ N. E. ½ S. W. ½ S.		E. ¾ W. W. ¾ N. E. ¾ S. W. ¾ S.		E. by N. W. by N. E. by S. W. by S.		E.N.E. ¾ E. W.N.W¾W E. S. E. ¾E. W.S.W.¾W		E.N.E. ½ E. W.N.W½W E.S. E. ½ E. W.S.W.½W		E. N. E. ¼ E. W.N.W.¼ W E. S. E. ¼ E. W.S.W. ¼W.		E. N. E. W.N.W. E. S. E. W.S.W.	

TABLE I.

COURSES CORRESPONDING TO THE POINTS.

	1/4 N.N.E. ¼ E. N.W.W. ¼ W S. S. E. ¼ E. S.S.W. ¼ W.		1/2 N.N. E. ½ E. N.N.W ½ W. S. S. E. ½ E. S S. W. ½ W.		3/4 N. N. E. ¾ E N. N.W. ¾ W. S. S. E. ¾ E. S. S. W. ¾ W.		0 N. E. by N. N. W. by N. S. E. by S. S. W. by S.		1/4 N. E. ¼ N. N. W. ¼ N. S. E. ¼ S. S. W. ¼ S.		1/2 N. E. ½ N. N. W. ½ N. S. E. ½ S. S W. ½ S.		3/4 N. E. ¾ N. N. W. ¾ N. S. E. ¾ N. S. W ¾ N.		0 N. E. N. W. S. E. S. W.	
DISTANCE.	2 Points.						3 Point.								4 Points	
	1/4		1/2		3/4		0		1/4		1/2		3/4		0	
	Lat.	Dept	Lat.	Dept	Lat.	Dept	Lat	Dept	Lat.	Dept	Lat.	Dept	Lat.	Dept.	Lat.	Dept.
100	94.4	42.8	88.2	47.1	85.8	51.4	83.1	55.6	80.3	59.6	77.3	63.4	74.1	67.2	70.7	70.7
200	180.8	85.5	176.4	94.3	171.5	102.8	166.3	111.1	160.6	119.1	154.6	126.9	148.2	134.3	141.4	141.4
300	271.2	128.3	264.6	141.4	257.3	154.2	249.4	166.7	241.0	178.7	231.9	190.3	222.3	201.5	212.1	212.1
10	09.0	04.3	08.8	04.7	08.6	05.1	08.3	05.6	08.0	06.0	07.7	06.3	07.4	06.7	07.1	07.1
20	18.1	08.6	17.6	09.4	17.2	10.3	16.6	11.1	16.1	11.9	15.5	12.7	14.8	13.4	14.1	14.1
30	27.1	12.8	26.5	14.1	25.7	15.4	24.9	16.7	24.1	17.9	23.2	19.0	22.2	20.1	21.2	21.2
40	36.2	17.1	35.3	18.9	34.3	20.6	33.3	22.2	32.1	23.8	30.9	25.4	29.6	26.9	28.3	28.3
50	45.2	21.4	44.1	23.6	42.9	25.7	41.6	27.8	40.2	29.8	38.7	31.7	37.0	33.6	35.4	35.4
60	54.2	25.7	52.9	28.3	51.5	30.8	49.9	33.3	48.2	35.7	46.4	38.1	44.5	40.3	42.4	42.4
70	63.3	29.9	61.7	33.0	60.0	36.0	58.2	38.9	56.2	41.7	54.1	44.4	51.9	47.0	49.5	49 5
80	72.3	34.2	70.6	37.7	68.6	41.1	66.5	44.4	64.3	47.7	61.8	50.8	59.3	53.7	56.6	56.6
90	81.4	38.5	79.4	42.4	77.2	46.3	74.8	50.0	72.3	53.6	69.6	57.1	66.7	60.4	63.6	63.6
1	00.9	00.4	00.9	00.5	00.9	00.5	00.8	00.6	00.8	00.6	00.8	00.6	00.7	00.7	00.7	00.7
2	01.8	00.9	01.8	00.9	01.7	01.0	01.7	01.1	01.6	01.2	01.5	01.3	01.5	01.3	01.4	01.4
3	02.7	01 3	02.6	01.4	02.6	01.5	02.5	01.7	02.4	01.8	02.3	01.9	02.2	02.0	02.1	02.1
4	03.6	01.7	03.5	01.9	03.4	02.1	03.3	02.2	03.2	02.4	03.1	02.5	03.0	02.7	02.8	02.8
5	04.5	02.1	04.4	02.4	04.3	02.6	04.2	02.8	04.0	03.0	03.9	03.2	03.7	03.4	03.5	03.5
6	05.4	02.6	05.3	02.8	05.1	03.1	05.0	03.3	04.8	03.6	04.6	03.8	04.4	04.0	04.2	04.2
7	06.3	03.0	06.2	03.3	06.0	03.6	05.8	03.9	05.6	04.2	05.4	04.4	05.2	04.7	04.9	04.9
8	07.2	03.4	07.1	03.8	06.9	04.1	06.7	04.4	06.4	04.8	06.2	05.1	05.9	05.4	05.7	05.7
9	08.1	03.8	07.9	04.2	07.7	04.6	07.5	05.0	07.2	05.4	07.0	05.7	06.7	06.0	06.4	06.4
DISTANCE.	Dept.	Lat.	Dept.	Lat.	Dept.	Lat.	Dept.	Lat.	Dept.	Lat.	Dept	Lat.	Dept.	Lat.	Dept.	Lat.
	3/4		1/2		1/4		0		3/4		1/2		1/4		0	
	5 Points.								4 Points.							
	N.E. by E¾E. NWbyW¾W S.E. by E ¾ E SW.byW¾W		N.E. by E½ E NWbyW½W S.E.by E.½E. SW.byW½W		N.E by E.¼E. NWbyW¼W S.E.by E.¼E. SW.byW¼W		N. E. by E. N. W. by W. S. E. by E. S. W. by W.		N. E. ¾ E. N. W. ¾ W. S. E. ¾ E. S. W. ¾ W.		N. E. ½ E. N. W. ½ W. S. E. ½ E. S. W. ½ W.		N. E. ¼ E. N.W. ¼ W. S. E. ¼ E. S. W. ¼ W		N. E. N. W. S. E. S. W.	

TABLE II.

MULTIPLIERS TO CONVERT MILES OF DEPARTURE INTO MINUTES OF LONGITUDE.

Middle Latitude.	Multiplier.	Middle Latitude.	Multiplier.	Middle Latitude.	Multiplier.	Middle Latitude.	Multiplier.	Middle Latitude.	Multiplier.	Middle Latitude.	Multiplier.	Middle Latitude.	Multiplier.	Middle Latitude.	Multiplier.
0°	1.00	10°	1.01	20°	1.06	30°	1.15	40°	1.30	50°	1.55	60°	2.00	70°	2.92
1	1.00	11	1.02	21	1.07	31	1.17	41	1.32	51	1.59	61	2.06	71	3.07
2	1.00	12	1.02	22	1.08	32	1.18	42	1.35	52	1.62	62	2.13	72	3.24
3	1.00	13	1.03	23	1.09	33	1.19	43	1.37	53	1.66	63	2.20	73	3.42
4	1.00	14	1.03	24	1.09	34	1.21	44	1.39	54	1.70	64	2.28	74	3.63
5	1.00	15	1.03	25	1.10	35	1.22	45	1.41	55	1.74	65	2.36	75	3.86
6	1.00	16	1.04	26	1.11	36	1.24	46	1.44	56	1.79	66	2.46	76	4.13
7	1.00	17	1.05	27	1.12	37	1.25	47	1.47	57	1.84	67	2.56	77	4.45
8	1.00	18	1.05	28	1.13	38	1.27	48	1.49	58	1.89	68	2.67	78	4.81
9	1.00	19	1.06	29	1.14	39	1.29	49	1.52	59	1.99	69	2.79	79	5.24

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